H I L G A R D I A

A Journal of Agricultural Science Published by the California Agricultural Experiment Station

VOL. 17 MARCH, 1947 No. 7

A STUDY OF TRANZSCHELIA PRUNI-SPINOSAE ON PRUNUS SPECIES IN CALIFORNIA[1, 2]

CLAYTON O. SMITH[3]

INTRODUCTION

THE GENUS *Prunus* comprises a heterogeneous collection of plants originating in many different parts of the world. The foliage of these plants is at times attacked by plant rust caused by various species of *Tranzschelia.*

The plant-rust genus *Tranzschelia,* as established by Arthur(*1*)[4] in 1906, consisted of a number of macrocyclic and microcyclic species, one of the macrocyclic species being the heteroecious rust of *Prunus* spp., *T. pruni-spinosae* (Pers.) Diet., formerly described as *Puccinia pruni-spinosae* Pers., but now separated from *Puccinia* because of differences in morphological characters.

This rust of *Prunus* is world wide in its distribution and probably occurs wherever *Prunus* species are grown. It is widely distributed in Europe and occurs in Asia (China, India, and Japan), Africa (Egypt and Uganda), Australia, and New Zealand. In South America this rust is found where *Prunus* is indigenous, in the mountains of Brazil, Colombia, Uruguay, and Venezuela. It is also reported from Mexico and Central America. In the United States it is found in the eastern states and is especially prevalent in the southeastern states and along the Pacific coast.

Other species of *Tranzschelia* found on the foliage of *Prunus* spp. and described by Tranzschel and Litvinov (*11*) should be listed: *T. japonica* on *P. armeniaca* var. *Ansu* and on *P. mume; T. microcerasi* on *P. microcarpa* and on six other species of *Prunus,* all from Central Asia; and *T. arthurii* on *P. serotina,* in the United States "(Michigan, leg. C. H. Hicks; Iowa, leg. Holway)."

The present study concerns observations of the rust *Tranzschelia pruni-spinosae,* both natural infection and that induced by artificial inoculation, on different species of *Prunus* in California. The study has extended over a series of years, though many of the artificial inoculations were made during the years 1942 and 1943.

[1] Received for publication July 2, 1946.

[2] Paper No. 548, University of California Citrus Experiment Station, Riverside, California.

[3] Associate in the Experiment Station, Emeritus.

[4] Italic numbers in parentheses refer to "Literature Cited" at the end of this paper.

IMPORTANCE AND PERSISTENCE OF RUST ON PRUNUS SPECIES IN CALIFORNIA

The rust fungus *Tranzschelia pruni-spinosae* on *Prunus* spp. in California is variable in its severity from year to year, probably largely as a result of meteorological conditions, though isolated trees have been observed to be attacked year after year, even in years when rust was not especially prevalent.

Infection late in the season, near time of leaf fall, is not regarded as of much economic importance, although the rust may be abundant on the leaves at this

Fig. 1.—An apricot orchard infected with rust, *Tranzschelia pruni-spinosae*. Trees were nearly defoliated in July. (Photographed by J. T. Barrett.)

time and some hastening of leaf fall may result. But an infection early in the season (April or May) may spread under favorable conditions and cause premature defoliation in the summer and early autumn (July to September) and serious injury to the tree. Such defoliation may be especially severe on trees that hold infected, living leaves into the dormant period.

Goldsworthy and Smith (*6*) report an epidemic of rust that caused defoliation on cling peaches. Barrett (*2*) describes a defoliation of apricots (fig. 1) in southern California, caused by rust that overwintered and served as a source of inoculum for new shoot growth stimulated by early fall pruning. Rust is also severe at times on nursery stock.

It is not altogether certain how the inoculum is carried over the dormant season, but various ways have been suggested. Goldsworthy and Smith (*6*) found that one-year-old twigs of peach infected in the autumn formed pustules of urediospores the following spring. Dunegan and Smith (*5*) have shown that low temperatures greatly increase the longevity of the urediospores. It is possible, therefore, that the urediospores may live over winter on the leaves, especially on living leaves infected with rust.

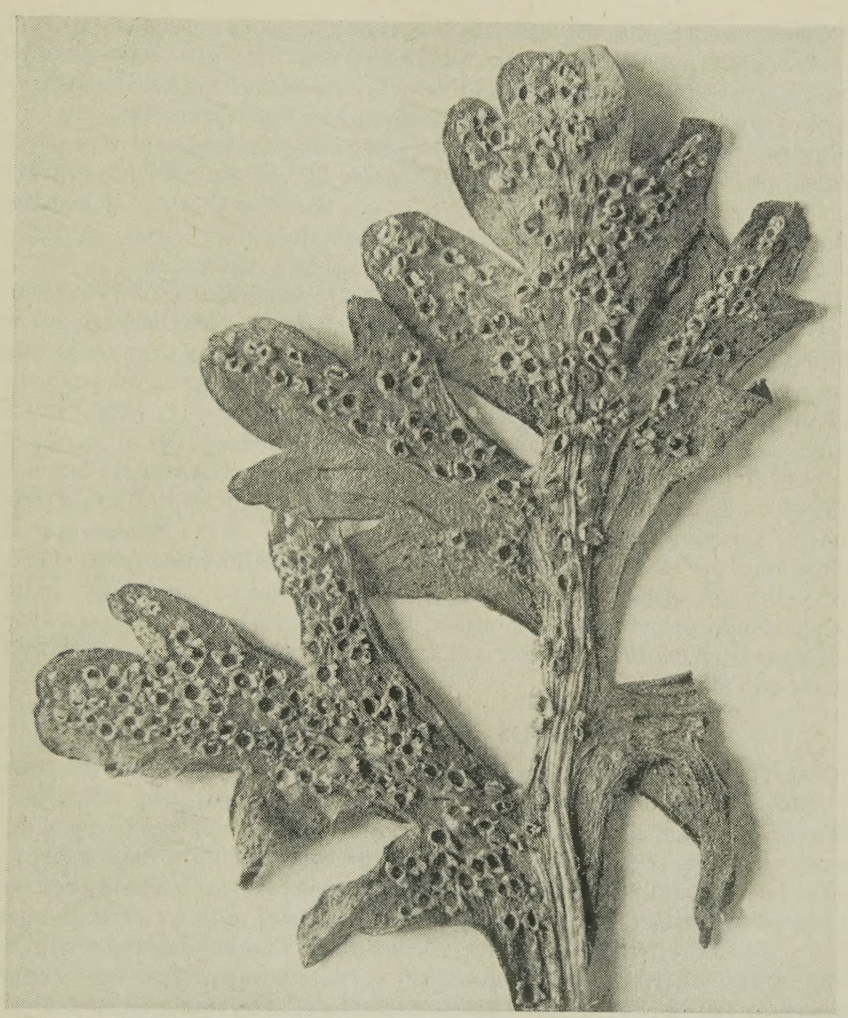

Fig. 2.—*Aecidium punctatum,* the alternate stage of the rust *Tranzschelia pruni-spinosae,* on *Anemone coronaria.* (Natural size.) (Collected by H. S. Fawcett in 1916. Photographed by J. T. Barrett.)

DIFFERENT RUST FORMS—THE TYPICA AND DISCOLOR TYPES AND THE CLUSTER-CUP OR AECIDIAL STAGE

Dunegan (*4*) has shown that there are two types of the rust *Tranzschelia pruni-spinosae* on *Prunus,* distinguished by the characteristics of the teliospores. In the typica type, the apical and basal cells of the two-celled teliospores are approximately the same shape, size, and color, and are uniformly coarsely verrucose over the entire surface. In the discolor type (regarded by some as *Tranzschelia discolor* Fuckel), the apical cell is globoid and coarsely verrucose over the entire surface, but the basal cell varies in shape from globoid to irregular, and its walls are never completely verrucose, in some specimens appearing almost entirely smooth.

Dunegan and Smith (*5*) describe differences in the germination of typica and discolor types of teliospores. The teliospores of typica type germinate near the apex of the apical cell and near the pedicel of the basal cell. In the discolor type, the germ tubes are produced near the septum.

The typica type of rust is found for the most part on the native or wild species of *Prunus*. The discolor type occurs almost entirely on cultivated species of *Prunus* (peach, apricot, almond, and the plum *P. domestica*), although Dunegan (*4*) has observed that certain native species of *Prunus* (*P. hortulana, P. mexicana,* and *P. besseyi*) are also susceptible.

The alternate or cluster-cup stage (*Aecidium punctatum*) of *Tranzschelia pruni-spinosae,* which develops on *Anemone* (fig. 2), has been found and studied in California by Scott and Stout (*7*), who observed that aecial spores were pathogenic on such cultivated species of *Prunus* as peach, almond, plum, and prune, but not on cherry. This stage apparently occurs rarely in California and is of limited importance. *Anemone coronaria,* the alternate host for rust of the discolor type, is planted in gardens in California but is not indigenous as it is in Europe, where it is apparently of considerable importance in carrying the rust over the dormant period of the *Prunus* spp. The indigenous species of *Anemone* and *Thalictrum* in California are for the most part mountain species and probably would be of limited importance as hosts if they should prove to be susceptible. In the United States, different species of *Anemone, Hepatica, Thalictrum,* and *Ranunculus* can be attacked by the cluster-cup stage.

METHODS OF INVESTIGATION

Observations and collection of rust material have been made over a series of years, in various parts of California, and notes have been taken on the presence or absence of rust on the different species of *Prunus* growing in mixed plantings and exposed to an abundance of inoculum from nearby infected peaches and plums (*P. domestica*). These observations have been made (1) in an experimental nursery at Riverside, where only a few of the peach rootstocks (Lovell seedlings) were successfully budded to other species of *Prunus,* and where the peach stock had sprouted and was severely infected with rust; (2) in experimental plots consisting of different species of *Prunus* growing in an irregular order of planting, located at Riverside and at Whittier, California, in the earlier years of this investigation; (3) in mixed experimental plantings at Moreno and Beaumont, California; and (4) in controlled experiments at Riverside, in which artificial inoculations of leaves on the more important species of *Prunus* were made to determine whether differences in pathogenicity would indicate distinct strains of rust, as reported by Thomas, Gilmer, and Scott (*10*) and suggested by field observations.

OBSERVATIONS OF RUST INFECTION IN AN EXPERIMENTAL NURSERY AND IN ORCHARD PLOTS

Observations of rust infection at Riverside, in an experimental nursery consisting of different species and varieties of *Prunus* budded on peach stock, extended over a two-year period, 1936–1937, inclusive. (The third year, 1938, showed so light a rust infection in this nursery that no data were available.)

The peach stocks were only in part budded to the other sorts, and were allowed to grow and serve as sources of inoculum, since they were severely infected with rust. All the trees, therefore, including those that escaped infection, must have been dusted with the rust spores at various times during the season. Rust infection in this nursery is summarized in table 1. Some of the hosts were severely infected in each of the two years; others of the host species were free from rust in one or both of the years.

TABLE 1

NATURAL RUST INFECTION OF *Prunus* SPP. IN AN EXPERIMENTAL NURSERY

Host species and source	December 12, 1936		October 8, 1937	
	Leaf infection*	Defoliation	Leaf infection*	Defoliation
Prunus amygdalus, Ne Plus Ultra almond	+	Slight	+	Slight
P. amygdalus, Nonpareil almond	+T	Medium	..	..
P. armeniaca, Royal apricot	+T	Medium	+	Slight
P. angustifolia var. *Watsonii*, seedlings	None	None	None	None
P. bokhariensis, P. I. 40224	None	None	None	None
P. cerasifera, from Arnold Arboretum	+T	Medium	+T	Medium
P. davidiana, seedling	..	..	+	Slight
P. davidiana, P.I. 36664	+	Medium	+T	Slight
P. hortulana, from Arnold Arboretum	?	None	+	None
P. mume, P.I. 47950	+	Medium	+T	Slight
P. munsoniana, from Arnold Arboretum	..	..	None	None
P. persica, seedling	+	Severe	+	Severe
P. salicina, Satsuma plum	+	None	Flecks	None
P. salicina, Wickson plum	..	..	+	None
P. tangutica, P.I. 40010	+	Severe	+	Severe
P. tomentosa, P.I. 36086	None	None	None	None
P. umbellata, seedling	+	Medium	+	Slight

* + = positive results indicated by leaf spot, uredia, and, usually, urediospore.
T = teliospore of discolor type present.

Observations of rust infection over a three-year period, 1936, 1937, and 1939, in orchard plots at Moreno and Beaumont, indicated an erratic occurrence of rust on the various species of *Prunus*. In both plots there was a miscellaneous collection of species and varieties of *Prunus*. Rust in the Moreno plot was largely on peach, however, and the intermingling of the rust-covered foliage of the peach with that of the other species afforded favorable conditions for infection. In the Beaumont plot rust was severe on almond all three years. The rust, in 1939, first appeared on almond trees that had been slightly rusted the previous year, and rapidly became severe, with defoliation beginning in July and continuing during the remainder of the year. Rust was well distributed over the almond planting early in the season, but was rare on peach until late in the season. Some of the almonds were topworked to varieties of *Prunus domestica* (French and Standard prunes) and *P. salicina* (Santa Rosa, Satsuma, and Wickson plums), the intermingling of the rust-covered foliage of the almond with that of the other species thus affording favorable conditions for infection.

Rust was observed in both plots on *Prunus armeniaca*, *P. amygdalus* (Ne Plus Ultra, Texas, Nonpareil, and I.X.L. varieties), *P. persica* (J. H. Hale,

Lovell, Babcock, Krummel, Elberta, and C. O. Smith varieties), and on *P. mahaleb* (mahaleb cherry). In the Moreno plot, rust was also observed on *P. besseyi, P. cerasifera* var. *Pissardii, P. davidiana, P. emarginata,* and *P. mume.* Rust was not observed in either the Moreno or the Beaumont plot on *P. avium* (mazzard cherry), *P. cerasifera* (myrobalan plum), *P. virginiana*

Fig. 3.—Cheesecloth chambers enclosing young trees of *Prunus* spp. inoculated with rust from various species of *Prunus.* Above the chambers are shown the containers from which water was conducted by means of cheesecloth wicks to the walls of the chambers, to provide moisture during the period of fungus incubation.

var. *demissa, P. domestica* (except on French prune, which showed a few uredia on the old leaves late in December), *P. bokhariensis, P. hortulana, P. salicina,* and *P. marianna* (hybrid).

METHODS AND RESULTS OF ARTIFICIAL INOCULATIONS OF PRUNUS SPECIES

Thomas, Gilmer, and Scott (*10*) made artificial cross-inoculations with urediospores of *Tranzschelia pruni-spinosae* (probably of the discolor type) on detached leaves of different species of *Prunus.* Their results suggested that different strains of rust existed on *Prunus.* In order to test their results more

conclusively, further experiments in the present series were conducted with growing plants under controlled conditions.

Small nursery trees of different species of *Prunus* (Lovell peach, Standard prune, Nonpareil almond, and others) were planted in peat and placed in cold storage from time of digging until the following September 1 (approximately 5 months), when they were transferred to 5-gallon containers and grown in

TABLE 2

RESULTS OF ARTIFICIAL INOCULATIONS OF TREES OF *Prunus* SPP. IN LATHHOUSE CHAMBERS, WITH RUST (*Tranzschelia pruni-spinosae*) FROM VARIOUS SOURCES*

Host	Source of inoculum and results†					
	P. amygdalus (almond)	*P. fenzliana* (Fenzyl almond)	*P. persica* (peach)	*P. pumila* (sand cherry)	*P. insititia* (Damson plum)	*P. mahaleb* (mahaleb cherry)
Prunus alleghaniensis	..	..	+	..	..	..
P. amygdalus	+	+	+	+	+	..
P. angustifolia var. *Watsonii*	+	+	+	..	+	..
P. armeniaca	+	..	+	+	+	..
P. besseyi	..	..	+	..	..	..
P. bokhariensis	..	..	None	..	None	..
P. caroliniana	..	..	+	+	..	..
P. davidiana	..	..	+	..	..	..
P. domestica	Slight	+	Flecks	+	+	..
P. emarginata	+	..	..	..	..	..
P. fasciculata	..	..	..	..	+	..
P. fremontii	..	..	+	+	+	..
P. hortulana	..	..	None	..	None	..
P. mahaleb	+	..	+	+	..	..
P. maritima	+	+	+	+	+	..
P. mexicana	..	..	..	+	None	..
P. mume	..	..	..	..	+	..
P. munsoniana	+	..	+	..	+	..
P. orthosepala	..	..	..	+	..	..
P. persica	+	+	+	+	+	+
P. pumila	..	..	+	..	..	+
P. salicina	None	+	None	+	+	..
P. texana	..	..	+	+	+	..
P. umbellata	..	..	None	None	+	..

* Almond rust from trees of *P. amygdalus* at the Moreno plot and *P. fenzliana* at Riverside; peach rust from *P. persica* in Orange County, at San Jose, near Riverside, and at Hemet; plum rust from *P. insititia*, Citrus Experiment Station.

† + = positive results indicated by leaf spot, uredia, and urediospores.

a lathhouse. The trees, after transplanting, were surrounded at once with cheesecloth chambers (fig. 3) to protect them from outside sources of infection and to provide chambers that could be moistened by means of water conducted from overhead containers through cheesecloth wicks (fig. 3). Inoculation of these trees was made by first wetting the foliage with water. Twigs with rust-covered leaves were then moved about among the wet foliage and left suspended in the cheesecloth chambers. Dunegan and Smith (5) have determined that three hours are sufficient to give good germination of the urediospores from peach. The walls of the chambers were therefore kept moist for several hours after inoculation. The results of two years' experiments are presented in table 2.

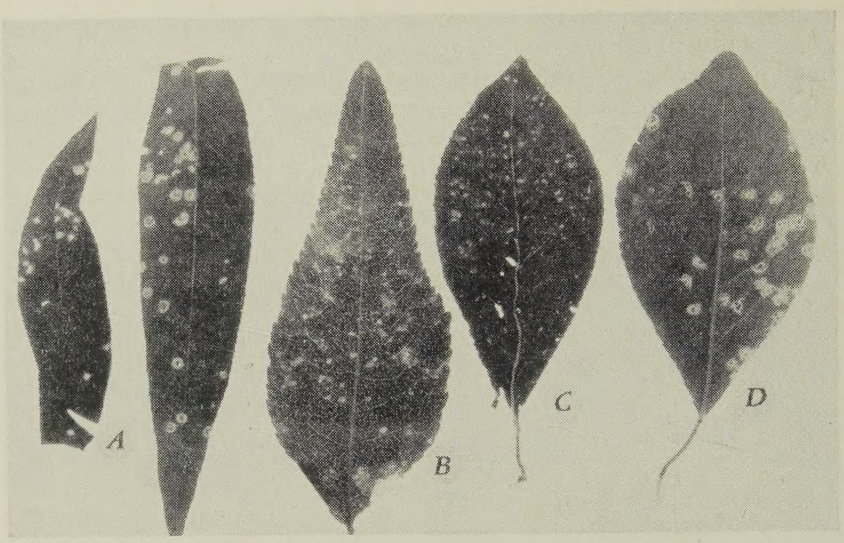

Fig. 4.—Rust infection on leaves of *Prunus* spp. artificially inoculated with rust from French prune: *A*, peach (*P. persica*); *B*, Nonpareil almond (*P. amygdalus*); *C*, Satsuma plum (*P. salicina*); and *D*, Standard prune (*P. domestica*).

TABLE 3

RUST INFECTION ON TREES OF *Prunus* SPP. THREE WEEKS AFTER INOCULATION MADE BY HANGING TWIGS WITH RUST-INFECTED LEAVES AMONG THE HEALTHY FOLIAGE DURING A NOVEMBER SHOWER

Host	Source of inoculum*	Infection†
Prunus amygdalus	Damson plum	+
P. amygdalus	Peach	+
P. angustifolia var. *Watsonii*	Damson plum	+
P. armeniaca	Damson plum	+
P. besseyi	Peach	+
P. bokhariensis	Peach	None
P. davidiana	Peach	+
P. domestica	Peach	None
P. domestica	Damson plum	+
P. fasciculata	Damson plum	+
P. fremontii	Damson plum	+
P. hortulana	Peach	None
P. mexicana	Peach	None
P. mume	Damson plum	+
P. salicina	Damson plum	+
P. texana	Damson plum	+

* *Prunus insititia* (Damson plum) and *P. persica* (peach).
† + = positive results indicated by leaf spot, uredia, and urediospores.

In another experiment, twigs with rust-covered leaves were tied among the healthy foliage of different species of *Prunus* during a November rain of several hours' duration. The results are presented in table 3.

The first indication of infection is the appearance of small yellow spots on the leaves about 25 days after inoculation. Artificial inoculations with rust

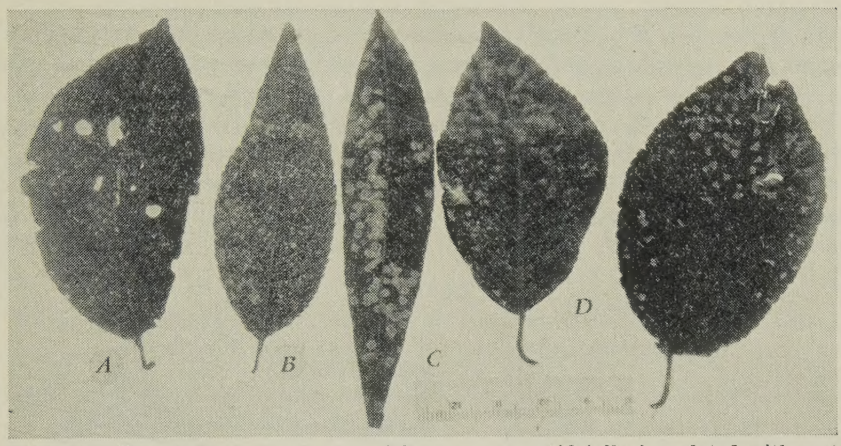

Fig. 5.—Rust infection on leaves of *Prunus* spp. artificially inoculated with rust from Damson plum (*P. insititia*): *A*, Satsuma plum (*P. salicina*, limited infection); *B*, almond (*P. amygdalus*); *C*, peach (*P. persica*); and *D*, Standard prune (*P. domestica*).

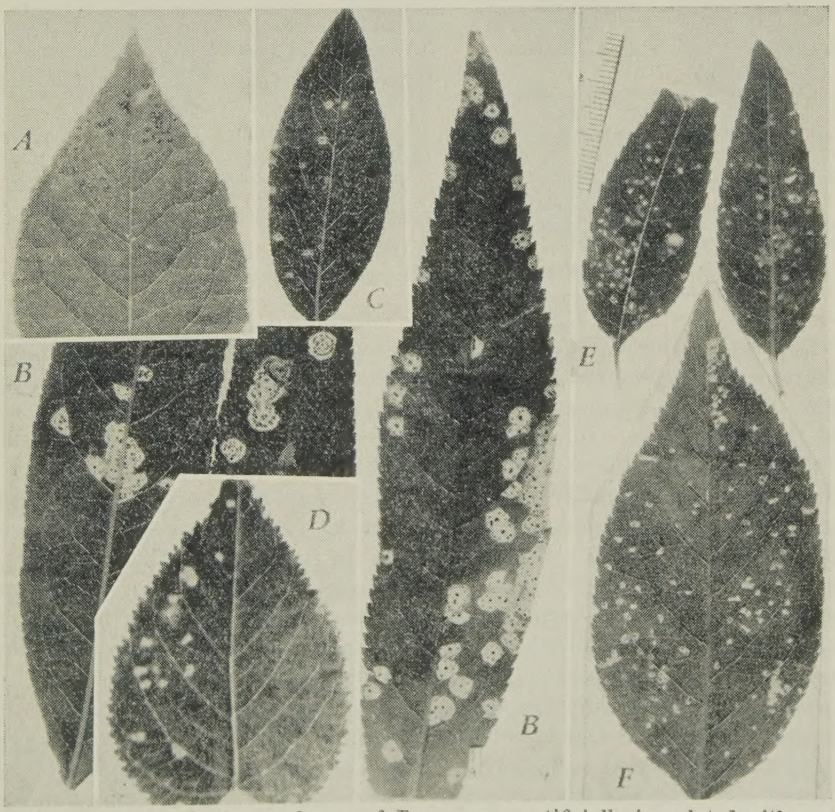

Fig. 6.—Rust infection on leaves of *Prunus* spp. artificially inoculated with rust from peach: *A*, *P. maritima* (lesions poorly developed); *B*, *P. persica* (note circular arrangement of the uredia); *C*, *P. angustifolia*; *D*, *P. armeniaca*; *E*, *P. amygdalus* (bitter almond); *F*, *P. alleghaniensis*. Inoculations of *E* and *F* were with rust from Brownwood, Texas.

from peach, almond, prune, and Damson plum caused typical rust spots on leaves of Lovell peach. Positive results of rust infection on leaves of peach, almond, Satsuma plum, and Standard prune with spores from French prune and Damson plum (figs. 4 and 5) have been produced repeatedly and have thus differed from the results of Thomas, Gilmer, and Scott (*10*), who report negative results on almond, peach, and cherry with spores from prune.

As shown in figure 6 and table 2, rust from peach is pathogenic in different degrees on different species of *Prunus*. On almond, this rust gave yellow leaf spots and a fair degree of infection, with the sori usually somewhat better

TABLE 4

RESULTS OF ARTIFICIAL INOCULATION OF ALMOND (*Prunus amygdalus*), APRICOT (*P. armeniaca*), AND PEACH (*P. persica*) WITH RUST SPORES FROM SOURCES INDICATED

Source of inoculum	Positive results of inoculations on		
	Almond	Apricot	Peach
Peach (Moreno)	Abortive sori	Yellow spots, 3–5 mm diam.	Yellow spots, 3–10 mm diam.
Peach (Hemet)*	Abortive sori	Yellow spots, 3–5 mm diam.	Yellow spots, 3–5 mm diam.
Peach (Hemet)*	Abortive sori	Yellow spots; fruiting	Yellow spots, 1–2 mm diam.
Almond (Moreno)	Sori plump and numerous	Sori poorly developed	Yellow spots, 1 mm or less in diam.; fruiting scant
French prune (San Jose)	Slight infection; fruiting	Yellow spots	Yellow spots, 1 mm or less in diam.
French prune (San Jose)	Sori; fair fruiting	Well-developed yellow spots	Yellow spots; sori plump; fruiting
Sugar plum (San Jose)	Sori few but well formed	Slight fruiting	Yellow spots
Damson plum (Riverside)	Spots; slight fruiting	Purple spots	Purplish spots

* Teliospores numerous.

developed than those of almond rust on peach. Rust from peach, from Hemet, with telia and uredia, produced positive results on almond, apricot, and peach (table 4). Results of peach rust on Standard prune were so slight, however, that they might be considered to be negative: some very small spots could be detected with a hand lens, and a few uredia were found near the leaf margins.

Inoculations with rust from almond (fig. 7) were positive on peach (*Prunus persica*), almond (*P. amygdalus*), and apricot (*P. armeniaca*), and on some other species of *Prunus* (tables 2 and 4). On peach leaves the rust spots resembled rust from peach on peach. The uredia were often poorly developed, but were sometimes of normal size. Telia were observed in limited numbers on almond, but not on peach or apricot. Small spots were apparently developed on some of the leaves of Standard prune, but these were less than 1 mm in diameter, were without uredia, and their cause could not be determined with certainty. In fact, the rust was so poorly developed on Standard prune as best to be regarded as negative. Rust from almond gave negative results on *P. salicina*. Results with rust from *P. fenzliana* (table 2) were similar to those with rust from almond, except for positive results (small spots) on *P. salicina*.

Rust inoculations with spores from *Prunus domestica* (French prune) and from *P. insititia* (Damson plum) gave similar results (figs. 4 and 5) on the different hosts tested. The two rusts have a similar appearance on the leaves of their respective hosts and develop telia late in the season. Rust inoculations from French prune produced small spots 1 to 3 mm in diameter on leaves of Nonpareil almond (fig. 4, *B*). A few uredia and spores were produced, but the sori were often white and undeveloped, no telia were observed, and the rust development was abnormal. This same rust formed small spots, with uredia and spores, on leaves of Satsuma plum (fig. 4, *C*). On peach leaves (figs. 4, *A*, and 5, *C*) rust from French prune and from Damson plum readily produced spots and spores characteristic of rust from peach on peach.

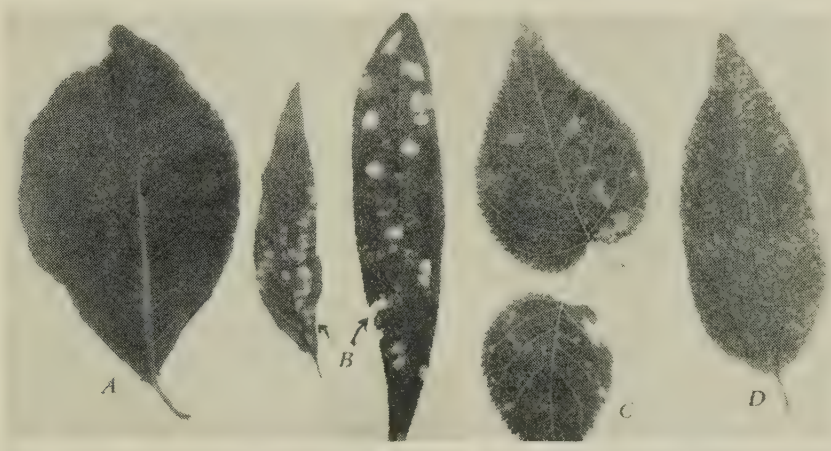

Fig. 7.—Rust infection on leaves of *Prunus* spp. artificially inoculated with rust from almond: *A*, Standard prune; *B*, peach; *C*, apricot; *D*, almond.

The very light infection resulting when Standard prune (*Prunus domestica*) was inoculated with rust from almond and peach (*P. persica*), and the severe infection when Standard prune was inoculated with rust from plum, suggest that these rusts may represent two different strains.

VARIABILITY OF UREDIA

Observations in the present experiments indicate that the uredia of the plant rust *Tranzschelia pruni-spinosae* from different sources are variable in size and color when growing on different species of *Prunus*. Similar differences in size have also been observed by Cristinzio (*3*) in Italy.

Natural rust infection on Wickson plum (of unknown source) had lesions 1 to 2 mm in diameter, with white uredia and few urediospores. Rust from Damson plum developed white, abortive uredia on almond and on Satsuma plum, where often only small flecks were formed. It is probable that there is considerable variation in the size and color of the uredia on other Japanese plums. The uredia on the semiwild species of *Prunus persica* (P.I. 40001 and 40864) and on J. H. Hale peach were small in comparison with those on Lovell peach seedlings. The uredia on Lovell peach were larger (0.5 to 3. mm diam.) and more numerous than the sori on J. H. Hale (0.5 to 1 mm diam.).

The commercial almonds of California also show variation in the uredia. The variety having the smallest, poorest-developed uredia is Ne Plus Ultra; the I.X.L. variety has medium-sized uredia, while uredia on Texas and Nonpareil are large and well developed. *Prunus fenzliana* (P.I. 27336) has large, well-developed uredia. On peach leaves, with peach rust (fig. 6, *B*), the uredia often have a circular arrangement on the leaf spot.

TABLE 5

SPECIES OF *Prunus* ON WHICH THE RUST *Tranzschelia pruni-spinosae* (DISCOLOR TYPE) HAS BEEN OBSERVED IN CALIFORNIA*

Species	Description	Species	Description
Prunus amygdalus	Nonpareil almond*	*P. mira*	Seedling*
P. amygdalus	P.I. 29218*	*P. mume*	P.I. 47950*
P. amygdalus	P.I. 30408	*P. mume*	P.I. 46694*
P. andersonii	Seedling	*P. munsoniana*	Seedling
P. angustifolia†	Seedling	*P. persica*	P.I. 40001*
P. armeniaca	Royal apricot	*P. persica*	P.I. 40000
P. armeniaca	P.I. 39464	*P. persica*	P.I. 41395
P. armeniaca var. *mandshurica*	Manchurian apricot	*P. persica*	P.I. 34685
		P. persica	Lovell peach
P. besseyi‡	Western sand cherry	*P. persica* x *P. amygdalus*	Hybrid almond x Peento peach
P. brigantina	P.I. 65051		
P. bucharica	P.I. 30975	*P. persica*	Flat peach
P. cerasifera	Myrobalan plum*	*P. persica*	Indian peach*
P. dasycarpa‡	Purple apricot	*P. persica*	Peento hybrid*
P. davidiana	P.I. 36664*	*P. pumila*	Seedling*
P. davidiana	P.I. 26604	*P. salicina*	Wickson plum
P. domestica	Clyman plum	*P. salicina*	Santa Rosa plum
P. domestica	French plum*	*P. salicina*	Satsuma plum
P. domestica	Reine Claude*	*P. sibirica*‡	P.I. 68819
P. domestica	Tragedy plum*	*P. simonii*	P.I. ?
P. emarginata	Seedling*	*Prunus* sp.	Marianna*
P. fasciculata	Seedling*	*Prunus* sp.	P.I. 55941
P. fenzliana	P.I. 27336*	*Prunus* sp.	P.I. 40864*
P. fremontii	Seedling*	*P. subcordata*	Seedling
P. insititia‡	Black Bullace*	*P. tangutica*	P.I. 40010
P. kansuensis	P.I. 68976*	*P. texana*‡	Seedling*
P. mahaleb‡	P.I. Lucie*	*P. umbellata*	P.I. 38974
P. mexicana	Seedling		

* The asterisk indicates that the discolor type of teliospore was observed.
† Infected by artificial inoculation.
‡ Specimen collected at San Jose, California. Unless otherwise specified, all material was collected in southern California, mostly at Riverside and Whittier.

OBSERVATIONS OF RUST ON DIFFERENT SPECIES OF PRUNUS IN CALIFORNIA

The different species of *Prunus* on which rust has been observed in California are listed in table 5. The discolor type was the only one found, and probably is the only form occurring in California. Herbarium specimens have been deposited in the collection at the University of California Citrus Experiment Station at Riverside, and duplicate specimens have been deposited in the herbarium at the University of California at Berkeley.

Smith and Cochran (*9*) have shown that the native California species *Prunus andersonii, P. emarginata, P. fasciculata, P. fremontii,* and *P. subcordata* are susceptible to the discolor type of rust when grown under culti-

vation and subject to natural infection. *P. virginiana* var. *demissa* is apparently not attacked. Smith (*8*) was successful in causing rust spots on the leaves of *P. ilicifolia, P. lyonii,* and *P. caroliniana.* There is no record of infection of any of these species in their natural habitats.

Certain species of *Prunus* native to the eastern United States were but slightly attacked with rust when grown in California under cultivation; others were extremely susceptible. Infected leaves were rare on *P. munsoniana, P. umbellata,* and *P. angustifolia* var. *Watsonii.* Artificial inoculation of the variety *Watsonii* (table 2), however, indicated that it was somewhat susceptible. *P. pumila, P. besseyi,* and *P. maritima* were extremely susceptible.

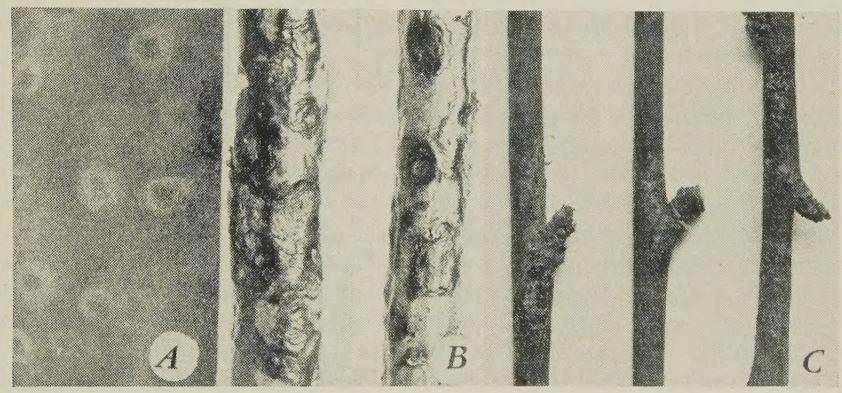

Fig. 8.—Natural rust infection on (*A*) fruit and (*C*) twigs of *Prunus persica,* and on (*B*) stems of *P. mume.* (*A* and *C* photographed by J. T. Barrett.)

Leaves of *P. mexicana* had brownish, circular spots, 1 to 3 mm in diameter, on which uredia developed; and urediospores from these spots were discernible under the microscope. Seedlings of *P. orthosepala* were almost free from rust infection. Some of the leaves on a few of the seedlings had small brownish spots, 1 to 2 mm in diameter, that showed poorly developed uredia.

The rust on peach (*Prunus persica*) usually shows only uredia. Telia, when formed, are seldom abundant; they were plentiful at times, however, on peach growing near Hemet. On two semiwild species from China (P.I. 40001 and 40864), the rust caused small purple spots, 1 to 2 mm in diameter, that had a few (usually 1 to 3) uredia. Only rarely were the leaves of these plants covered with rust as early or as completely as were those of the Lovell seedlings. The peach fruit (fig. 8, *A*) is occasionally attacked by rust, which causes circular spots with lighter-colored margins. Peach twigs (fig. 8, *C*) are also attacked, and the mycelium carried on the twigs through the dormant season serves as an initial source of inoculum for the new plant growth.

Seedlings of *Prunus fremontii* growing near *P. cerasifera* var. *Pissardii* produced trees having leaf characters closely resembling those of *P. cerasifera* and *P. cerasifera* var. *Pissardii* and were probably first-generation hybrids between these species and *P. fremontii.* All these seedlings were extremely susceptible to rust (of the discolor type, where teliospores were present and the type could be determined).

Rust on *Prunus domestica* develops uredia, followed by telia in abundance and almost a complete absence of uredia. Rust on almond (*P. amygdalus*), like that on *P. domestica,* produces uredia and later abundant telia.

Prunus caroliniana, an evergreen species native to the eastern United States, is susceptible to rust in California. Smith (*8*) has shown that *P. caroliniana* is naturally infected when grown near other species of *Prunus* that carry the inoculum. It has also been successfully infected artificially. The rust fruits sparingly, however, and the diseased tissue falls out and leaves a shot-hole effect.

Rust has been severe on *Prunus fenzliana* at the Citrus Experiment Station, and has caused early infection and marked defoliation. Leaves of the peach rootstock had definite spots with uredia, but defoliation was slight. The rust on *P. fenzliana* was apparently that of almond and it showed the development of telia, a characteristic of the rust as it develops on almond.

Prunus ilicifolia, a California evergreen species, has been successfully infected artificially by rust, according to Smith (*8*). Fruiting was sparse, but brownish spots surrounded with yellow-greenish zones were readily produced on the young leaves, though not on the older leaves.

Rust and definite lesions developed on the stems (fig. 8, *B*) of some of the seedlings of *Prunus mume* grown at the Citrus Experiment Station, but rust does not now appear to be present on the stems of the mature trees. Rust has been observed on leaves of other trees of *P. mume* at the Citrus Experiment Station.

Rust has not been observed occurring naturally in California on the following species: *Prunus bokhariensis* (P.I., 40223, 40224, and 40231), *P. avium* (successfully infected artificially with rust from *P. pumila*), *P. cerasus, P. hortulana, P. serotina, P. virginiana* var. *demissa, P. ilicifolia, P. yedoensis, P. majestica* Koehne (P.I. 55417), and *P. mira* (P.I. 34601). Tranzschel and Litvinov (*11*) state that forms of *Tranzschelia* are generally unknown on the cherry in Europe.

Other species of *Prunus* may sometimes show a shot-hole effect on the leaves as the result of an attack by rust. Evidence of this is seen in partially excised tissue on which rust sori are present. This effect has been noted on the two semiwild species of peach from China (P.I. 40001 and 40864) and on almond and apricot trees that were inoculated with urediospores from prune (*P. domestica*) and Damson plum (*P. insititia*).

SUMMARY

There are two different types of the rust *Tranzschelia pruni-spinosae* on *Prunus* spp., namely, the typica and the discolor types, as described by Dunegan (*4*). The discolor type is the only one that has been observed in California.

In the studies reported in the present paper, artificial inoculations of *Prunus* spp. with rusts from almond, peach, prune, and Damson plum usually showed some pathogenicity, although the development of the spots, the uredia, and the amount of fruiting were often far different on the different cultivated hosts. When species of *Prunus* were inoculated, the uredia were at times abortive. Peach and almond were susceptible to rust from almond, peach, and

prune. Standard prune and other varieties of *P. domestica,* as well as Damson plum (*P. insititia*), were susceptible to rust from prune and from Damson plum. Rust from peach and almond gave only light infection on Standard prune, in the form of very small spots that were so inconspicuous as to be readily overlooked, and that did not develop sori, except possibly a few near the leaf margin, but peach is severely infected by rust from Standard prune and Damson plum. Rust symptoms on almond are very similar to those on peach, the chief difference being in the abundant production of telia sori on almond.

Orchard observations and results from interspecific host inoculation tests indicate that the rusts on peach (*Prunus persica*) and on Standard prune (*P. domestica*) may represent at least two different strains.

ACKNOWLEDGMENTS

The writer wishes to express appreciation to Dr. L. C. Cochran, who provided experimental trees and gave many helpful suggestions during the investigation, and in whose experimental plots of *Prunus* spp. many of the observations on rust were made. Thanks are extended also to Dr. B. A. Rudolph, and to Mr. L. R. Cody, County Agricultural Commissioner, San Jose, for rust material on *P. domestica.* The writer is especially obligated to Dr. John C. Dunegan, who supplied a copy of the paper by Tranzschel and Litvinov (*11*), translated into English, from the Russian, by Dr. S. L. Jodidi (mycological terminology revised by John C. Dunegan).

LITERATURE CITED

1. Arthur, J. C.
1906. Eine auf die Struktur und Entwicklungsgeschichte begründete Klassifikation der Uredineen. Res. Sci. Cong. Internatl. de Bot. (Vienne) 1905:331–48.

2. Barrett, J. T.
1915. Observations on prune rust, *Puccinia pruni-spinosae* Pers., in Southern California. (Abstract) Phytopathology 5:293.

3. Cristinzio, M.
1936. Studio sulla ruggine delle drupacee (*Puccinia pruni-spinosae*, Pers.). Ricerche, Osservazionie Divulgazioni Fitopat. Campania ed Mezzogiorno [Portici (Napoli)] 5:15–60.

4. Dunegan, John C.
1938. The rust of stone fruits. Phytopathology 28:411–27.

5. Dunegan, John C., and Clayton O. Smith.
1941. Germination experiments with uredio- and teliospores of *Tranzschelia pruni-spinosae discolor*. Phytopathology 31:189–91.

6. Goldsworthy, M. C., and Ralph E. Smith.
1931. Studies on a rust of clingstone peaches in California. Phytopathology 21:133–68.

7. Scott, C. Emlen, and Gilbert L. Stout.
1931. *Tranzschelia punctata* on cultivated anemone in the Santa Clara Valley. California State Dept. Agr. Mo. Bul. 20:648–54.

8. Smith, Clayton O.
1945. Inoculations of the evergreen species of *Prunus* (*Laurocerasus*) with *Tranzschelia pruni-spinosae*. Phytopathology 35:572–74.

9. Smith, Clayton O., and L. C. Cochran.
1939. Rust on the California native *Pruni*. Phytopathology 29:645–46.

10. Thomas, H. Earl, Ralph A. Gilmer, and C. Emlen Scott.
1939. Rust of stone fruits. California State Dept. Agr. Mo. Bul. 28:322–27.

11. Tranzschel, V. G., and M. A. Litvinov.
1939. [Rust fungi of the genus *Prunus*.] [In Russian.] Jour. de Bot. 24:247–53.

4*m*-4,'47(A1441)